LIPIDS

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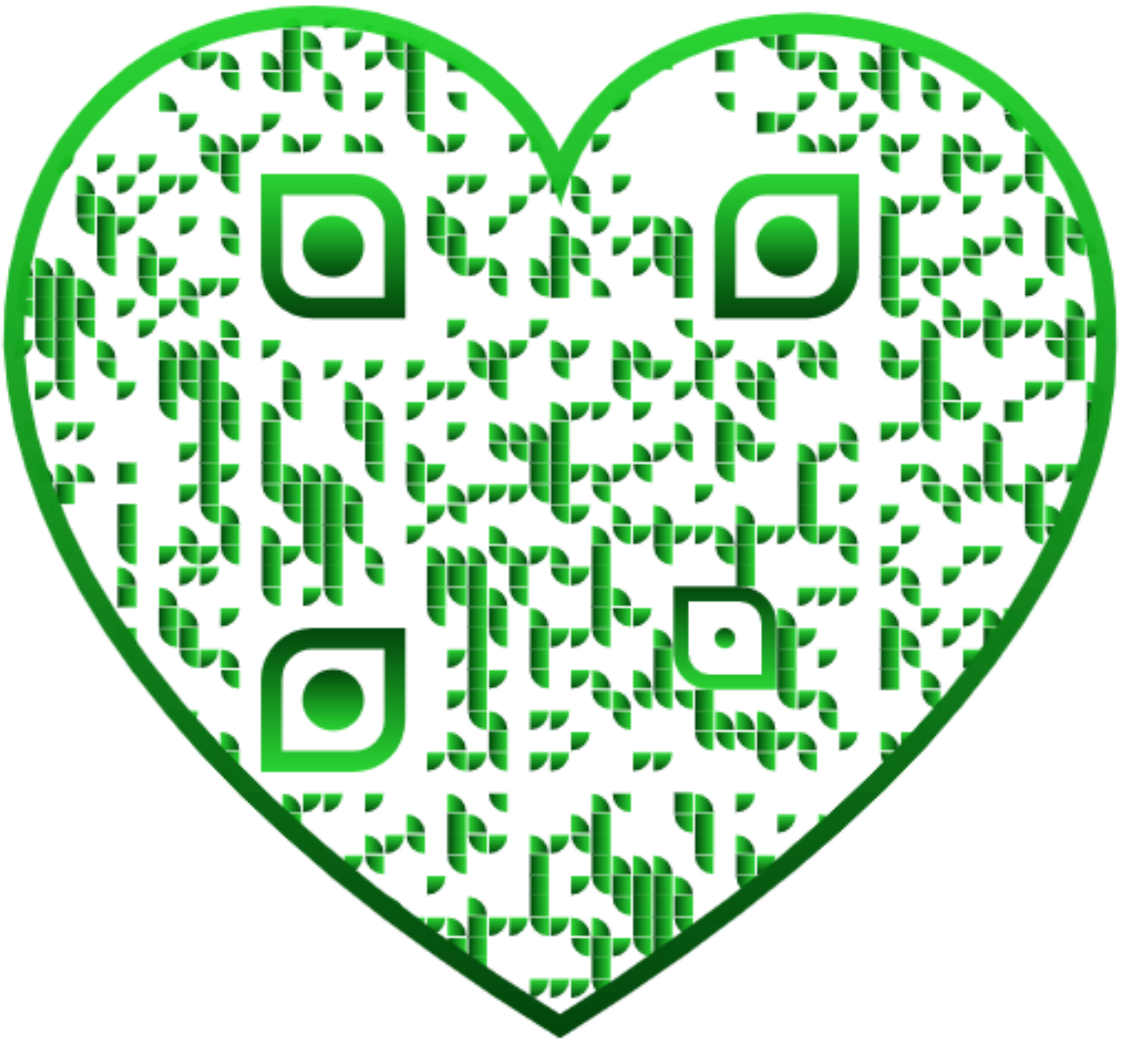


LIPIDS

Topic outline

1. Definition, occurrence and composition of fats, oils and waxes
   - 1.1 Definition, classification and nomenclature
   - 1.2 Occurrence and composition
2. Determination of analytical values for fats, oils and waxes
   - Iodine values
   - Saponification values
   - Acid values,
   - Ester values,
   - Acetyl values and others

LIPIDS cont

- Generally, lipids
  - ➢ are chemically heterogeneous group of substances, having in common the property of insolubility in water, but solubility in non-polar solvents
  - ➢ may include natural products such as fatty acids and their derivatives, steroids, terpenes, carotenoids and bile acids

LIPIDS cont.

- They are widely distributed in nature
- Can function as
  - Energy storage
  - Structure of cell membranes
  - Thermal blanket and cushion
  - Precursors of hormones (steroids and prostaglandins)

LIPIDS cont.

II. Lipid classifications & fatty acid nomenclature

I. Lipid classifications

- Different basis of classifications:

1. Physical properties at room temperature
   - **Oils** are liquid and
   - **Fats** are solid or semisolid

LIPID CLASS. cont

2. **Polarity (polar and neutral lipids)**
   - **Neutral** lipids include fatty acids, alcohols, glycerides, and sterols
   - **Polar** lipids include glycerophospholipids and glyceroglycolipids
3. **Essentiality for humans**
   - **Essential** and
   - **Nonessential** fatty acids

LIPID CLASS. cont

4. **Structure** (derived, simple or complex)

- The separation into polarity classes is rather arbitrary, as some short chain fatty acids are very polar
- A classification based on structure is, therefore, preferable.
- Based on structure, lipids can be classified as **derived, simple, or complex**.

LIPID CLASS. cont

- **Simple lipids**
  - composed of fatty acids and alcohol components,
  - include acylglycerols, ether acylglycerols, sterols, and their esters and wax esters.
- **Derived lipids**
  - include fatty acids and alcohols,
  - are the building blocks for the simple and complex lipids
-

LIPID CLASS. cont

- In general terms, simple lipids can be hydrolyzed to two different components, usually an alcohol and an acid.

- **Complex lipids**
  - include glycerophospholipids (phospholipids), glyceroglycolipids (glycolipids), and sphingolipids.
  - These structures yield three or more different compounds on hydrolysis.

LIPID cont.

2. FATTY ACID NOMENCLATURE

- FAs are obvious starting point in lipid structures.
- D/t nomenclature systems have been proposed.
- Here follow three main ones

FA NOMENCLATURE cont.

A. Standard IUPAC Nomenclature of Fatty Acids

- The FA is named after the parent hydrocarbon.
- For example,
  - an 18-C FA is called octadecanoic acid, from octadecane
  - The name octadecanecarboxylic acid may also be used, but it is more cumbersome and less common.

FA NOMENCLATURE cont.

- Double bonds are designated using the Δ configuration
  - Δ = distance from the –COOH
  - A double bond b/n the 9^{th} and 10^{th} Cs from –COOH is a Δ^9 bond.
  - The hydrocarbon name is changed to indicate the presence of the double bond.

FA NOMENCLATURE cont.

- An 18-C fatty acid
  - with one double bond to an octadecenoic acid,
  - with two double bonds octadecadienoic acid, and so on.
- The double-bond positions are designated with numbers before the fatty acid name
  - Δ^9-octadecenoic acid or simply 9-octadecenoic acid
  - The Δ is assumed and often not placed explicitly in structures.

FA NOMENCLATURE cont.

- Double-bond geometry is designated with the *cis–trans* or *E*/*Z* nomenclature systems.
- The prefixes *cis* and *trans* can be abbreviated as *c* and *t* in structural formulas.

FA NOMENCLATURE cont.

B. Common (Trivial) Nomenclature of FAs

- Trivial names for certain FAs are more common than standard (IUPAC) terminology.
- For example, oleic acid is much more common than *cis*-9-octadecenoic acid.
- Many of the common names originate from the first identified botanical or zoological origins for those fatty acids.
- Myristic acid is found in seed oils from the Myristicaceae family.

FA NOMENCLATURE cont.

C. Shorthand (ω) Nomenclature of FAs

- ω nomenclature are found in common usage
- The shorthand designation is
  - The carbon number in the FA chain
  - followed by a colon,
  - then the number of double bonds and the position of the double bond closest to the methyl side of the FA molecule.

FA NOMENCLATURE cont.

- The methyl group is number 1
  - the last character in the Greek alphabet is ω, hence the end
- In shorthand notation,
  - the unsaturated fatty acids are assumed to have *cis* bonding and,
  - if the fatty acid is polyunsaturated, double bonds are in the methylene interrupted positions.

FA NOMENCLATURE cont.

- Shorthand terminology cannot be used for
  - fatty acids with *trans* or acetylene bonds,
  - those with additional functional groups (branched, hydroxy, etc.), or
  - double-bond systems ($\geq$ 2 double bonds) that are not methylene interrupted (isolated or conjugated).

FA NOMENCLATURE cont.

- Sometimes the ω is replaced by n-(18:2n-6 instead of 18:2ω6).
  - Although there have been recommendations to eliminate ω and use n- exclusively, both n- and ω are commonly used in the literature and are equivalent.

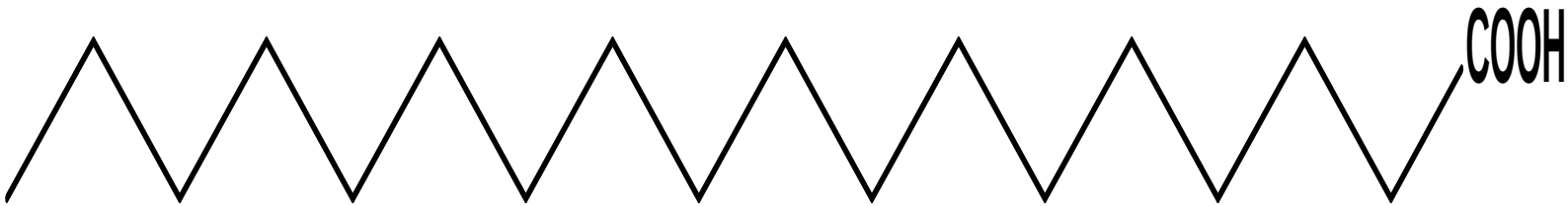
FA NOMENCLATURE cont.

- Shorthand designations for polyunsaturated fatty acids are sometimes reported without the ω term (18:3).
- However, this notation is ambiguous, since 18:3 could represent
  - 18:3 ω 1, 18:3 ω 3, 18:3 ω 6, or 18:3 ω 9; FAs,
  - which are completely different in their origins and nutritional significances.

FA NOMENCLATURE cont.

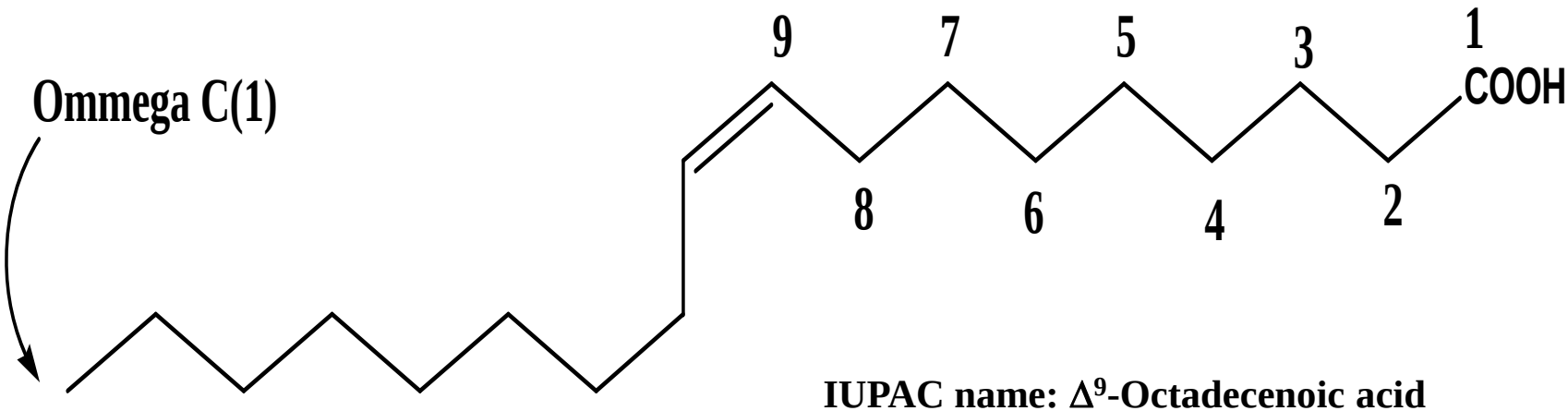
- Two or more fatty acids with the same carbon and double-bond numbers are possible in many common oils.
- Therefore, the ω terminology should always be used with the ω term specified.
- Example of nomenclature

A.



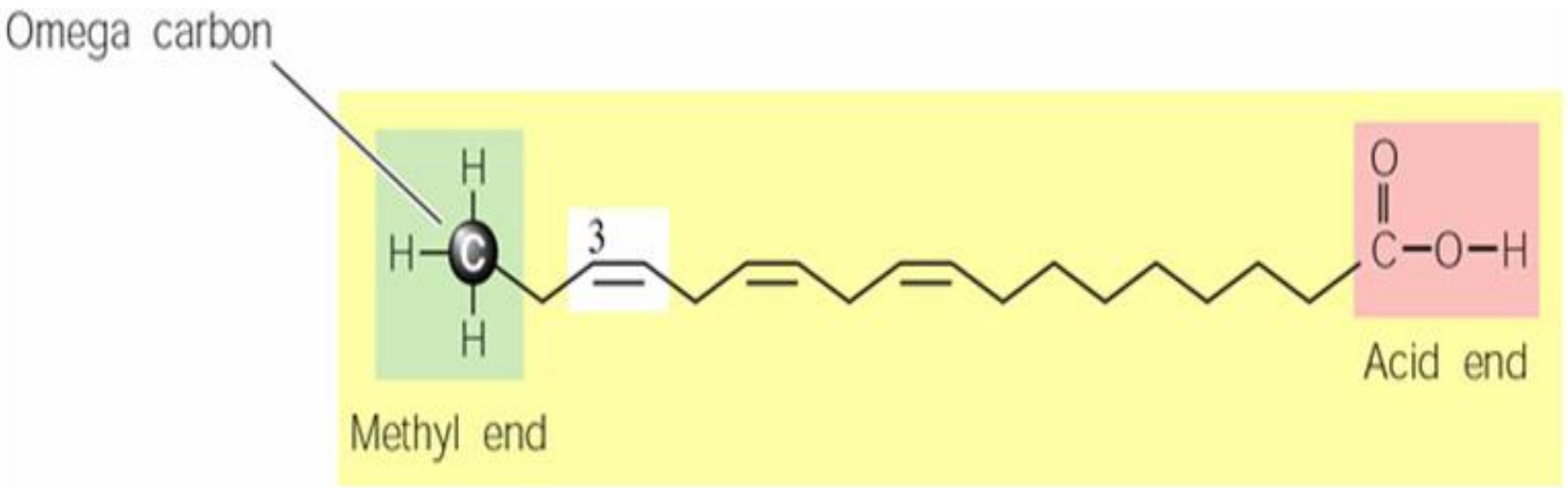
IUPAC name: Octadecanoic acid
Common name: Stearic acid
Shorthand name: 18:0

B.

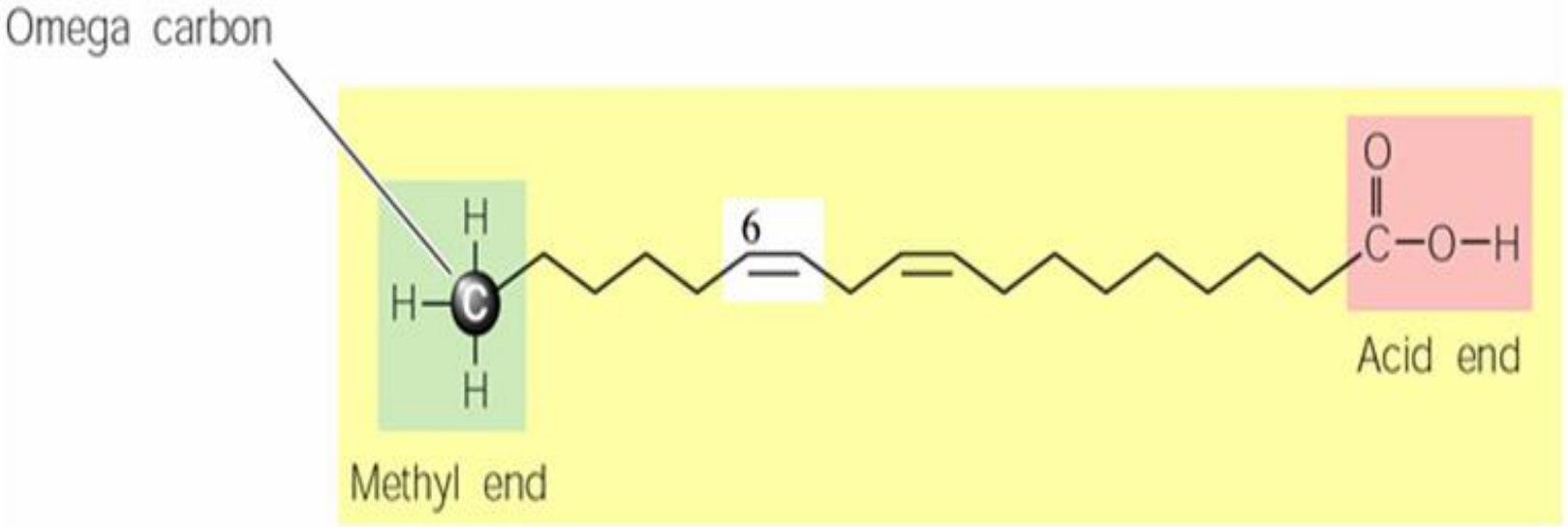


IUPAC name: Δ^9-Octadecenoic acid
Common name: Oleic acid
Shorthand name: (18:1 ω 9)

Figure: Illustrative example on nomenclature-saturated (A), unsaturated (B)



Linolenic acid, an omega-3 fatty acid



Linoleic acid, an omega-6 fatty acid

Unsaturated Essential Fatty Acids

LIPIDS cont.

- **III. LIPID CLASSES**

I. Derived lipids

A. Fatty Acids

- **Definition**
  - Fatty acids are aliphatic mono-carboxylic acids that are mostly obtained from the hydrolysis of natural fats and oils.

Derived lipids-FAs

- **Naturally-occurring Fatty Acids**
  - ✓ Even numbered
  - ✓ If there is unsaturation,
    - Cis form
    - Not conjugated --- isolated double bond.

Derived lipids-FAs

- Mostly have straight chain
  - a few exceptions have branched and heterocyclic chains or other functional groups
- In nature, almost all fatty acids have an even number of carbons.
  - This is due to the fact that fatty acids are synthesized stepwise from acetyl building blocks.
  - The 16- and 18-carbon fatty acids are most common

Derived lipids-FAs

- **Classification**
  - Fatty acids are classified according to several bases as follows:
    - ✓ According to presence of double bond(s)
      - ➢ **Saturated** – no double bond
      - ➢ **Unsaturated** – one or more double bond

Derived lipids-FAs

- ✓ According to chain length
- Short chain FAs: 2-4 carbon atoms
- Medium chain FAs: 6 –10 carbon atoms
- Long chain FAs: 12 – 26 or more carbon atoms

Derived lipids-FAs

- ✓ According to biosynthesis in the body:

- ➢ Essential FAs – those that cannot be biosynthesized in the body
  - examples: linoleic and linolenic acids
- ➢ Non-essential FAs - can be biosynthesized in the body

Derived lipids-FAs

- **General characteristics-** FAs are characterized by
  - Number of carbons (chain length)
  - Number of double bonds (degree of un-saturation)
  - Location and orientation of these bonds (non-conjugated, conjugated; *cis*, *trans*)

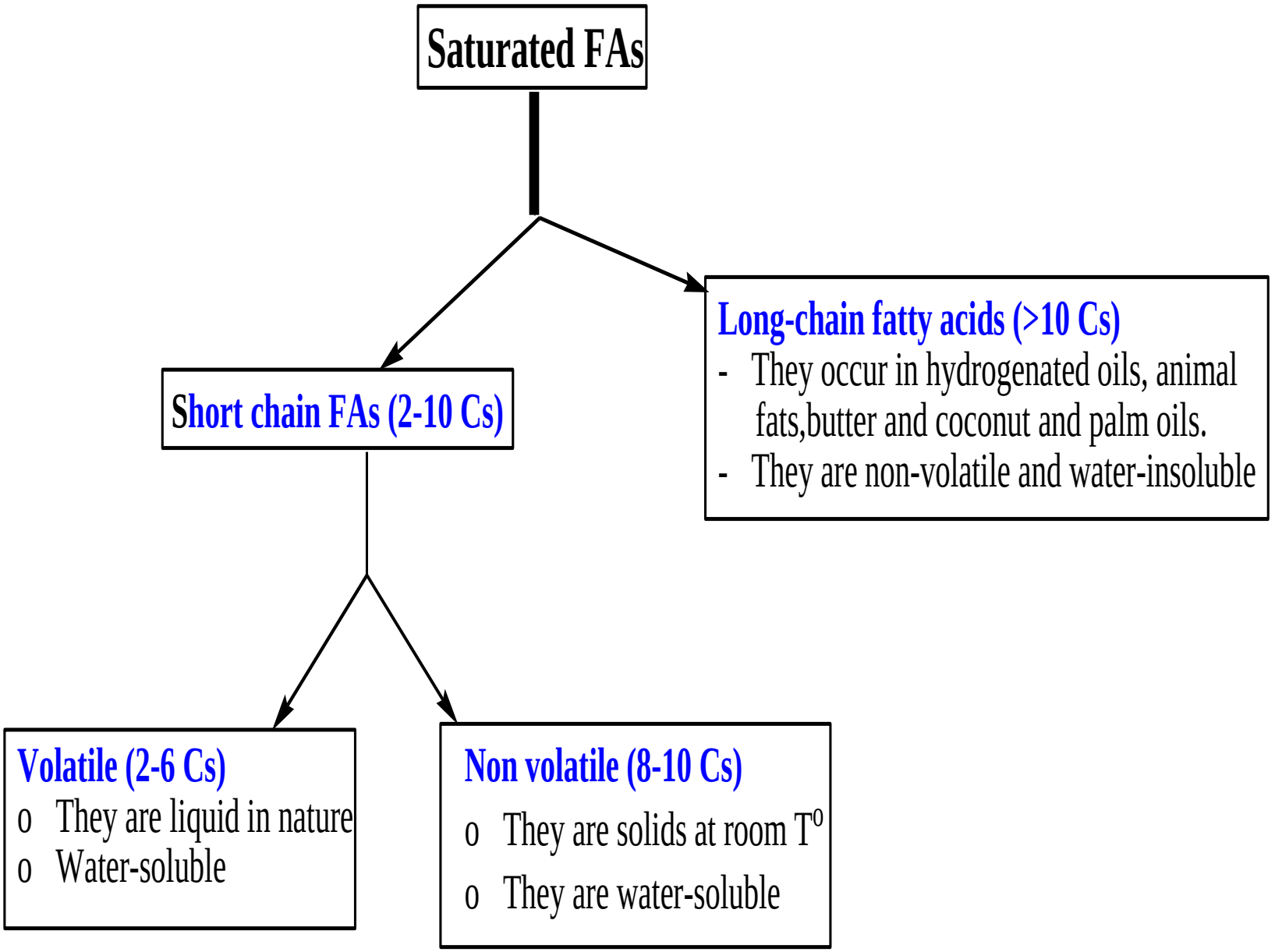
Derived lipids-FAs

- **Naturally less common FAs also exist and include:**
  - Acetylenic
  - Trans
  - Branched
  - Cyclic
  - Hydroxy and Epoxy and
  - Furanoid

Derived lipids-FAs

1. Saturated Fatty Acids

- Contain no double bonds
- Begin with methanoic (formic) acid
- Subclassified in to short & long chain FAs
- Are solid at room temp. except if they are short chained.


Saturated FAs
Long-chain fatty acids (>10 Cs)
- They occur in hydrogenated oils, animal fats,butter and coconut and palm oils.
- They are non-volatile and water-insoluble
Short chain FAs (2-10 Cs)
Volatile (2-6 Cs)
o They are liquid in nature
o Water-soluble
Non volatile (8-10 Cs)
o They are solids at room T0
o They are water-soluble

Derived lipids-FAs

2. Unsaturated Fatty Acids

- FAs may contain one or more double bonds and can thus be categorized in to:
  - Monounsaturated: contain one double bonds
  - Polyunsaturated: contain more the one double bond

Derived lipids-FAs

- Monounsaturated FAs
  - By far the most common is oleic acid (18:1ω9),
    - although >100 have been identified in nature.
  - The most common double-bond position for monoenes is Δ^9.

Derived lipids-FAs

- Polyunsaturated fatty acids (PUFAs)
  - are usually referred as essential FAs
  - The essentiality of ω 6 fatty acids has been known since the late 1920s.
  - Since the 1970s, evidence has accumulated illustrating the essentiality of the ω3 PUFA.

Derived lipids-FAs

- Not all PUFAs are essential FAs
  - some can be derived from other PUFAs
- The most common of the ω6 FAs in our diets is 18:2 ω 6.
- Source of PUFAs include:
  - Vegetable oils and many other plant oils, cod liver oil and animal fats.

Derived lipids-FAs

- The double bonds in natural PUFAs are separated by at least one methylene group
  - non- conjugated
- The C=C double bonds in almost all naturally occurring fatty acids have a ***cis*** configuration
- There are cases where ***trans*** double bonds are known, however, these are seldom found in membranes.

Derived lipids-FAs

Trans Fatty Acids

- Nomenclature differs from normal *cis* FAs only in the configuration of the double bonds.
- The main origins of *trans* FAs in our diet are
  - bacteria,
  - partially hydrogenated oils.

Derived lipids-FAs

- **Physico-chemical properties**

Physical Properties

- The physical properties of fatty acids are largely determined by the length and degree of unsaturation of the hydrocarbon chain.

Derived lipids-FAs

- Physical Properties of FAs (Length)- degree of un-saturation kept constant
  - The longer the fatty acid chain length,
    - the poorer the solubility in water
    - the higher the melting point.
- The polar nature of the carboxylic acid group accounts for the moderate solubility of short-chain (<10 Cs) fatty acids in water.

Derived lipids-FAs

- Physical Properties of Fatty Acids (Degree of Unsaturation) – chain length kept constant
  - The fewer the double bonds in a fatty acid
    - the lower the solubility in water.
    - the higher the melting point.
  - Effect of the configuration of double bond(s)
    - ***cis*** double bonds place kinks in the chains of unsaturated fatty acids

Derived lipids-FAs

- In saturated lipids, the most stable arrangement is very close packing of the side chains of the lipids
  - The packing is such that the lipids assume an almost crystalline array
- ***Trans*** fatty acids have an extended structure and can pack similarly to saturated fatty acids, and thus they have markedly higher melting points

Derived lipids-FAs

- Because of the kink that results from cis double bonds, tight packing of fatty acid chains cannot take place.
- Since the interactions between these arrays are less extensive, it takes less energy to disrupt them, resulting in a lower melting point

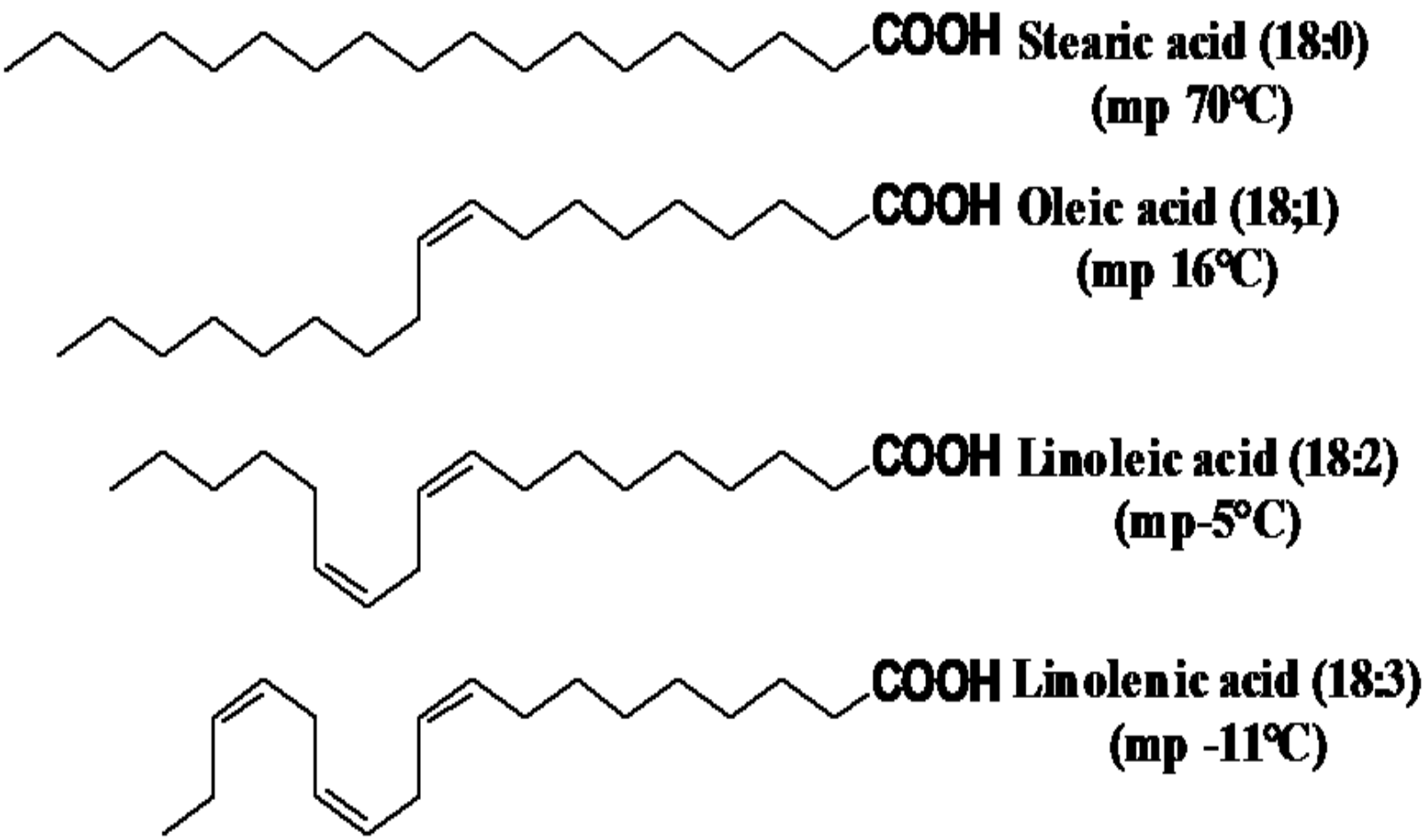
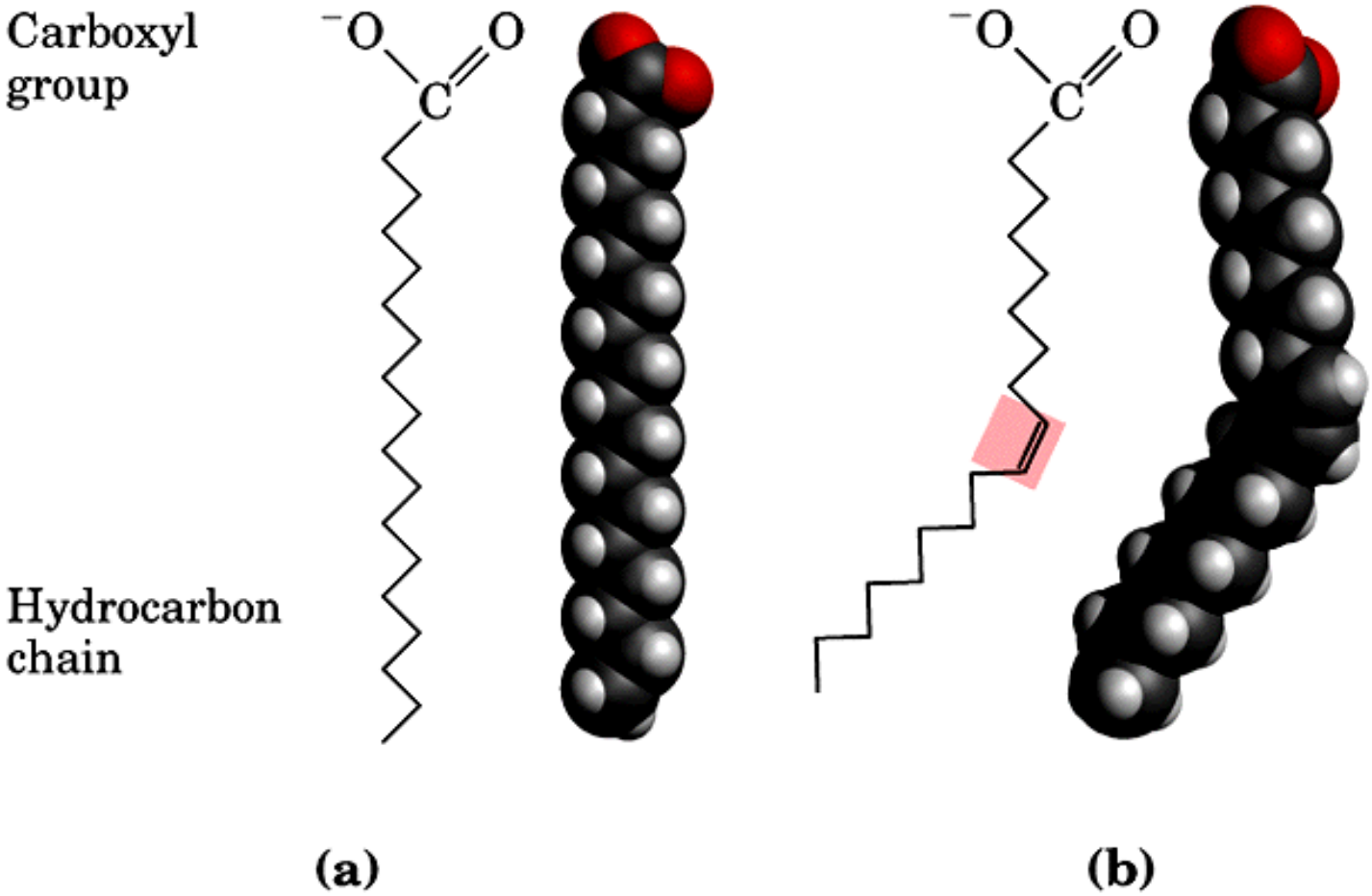


Figure : Lipid structure- C18 fatty acids, all double bonds cis, increasing number of double bond decreased mp


Carboxyl group
Hydrocarbon chain
(a)
(b)

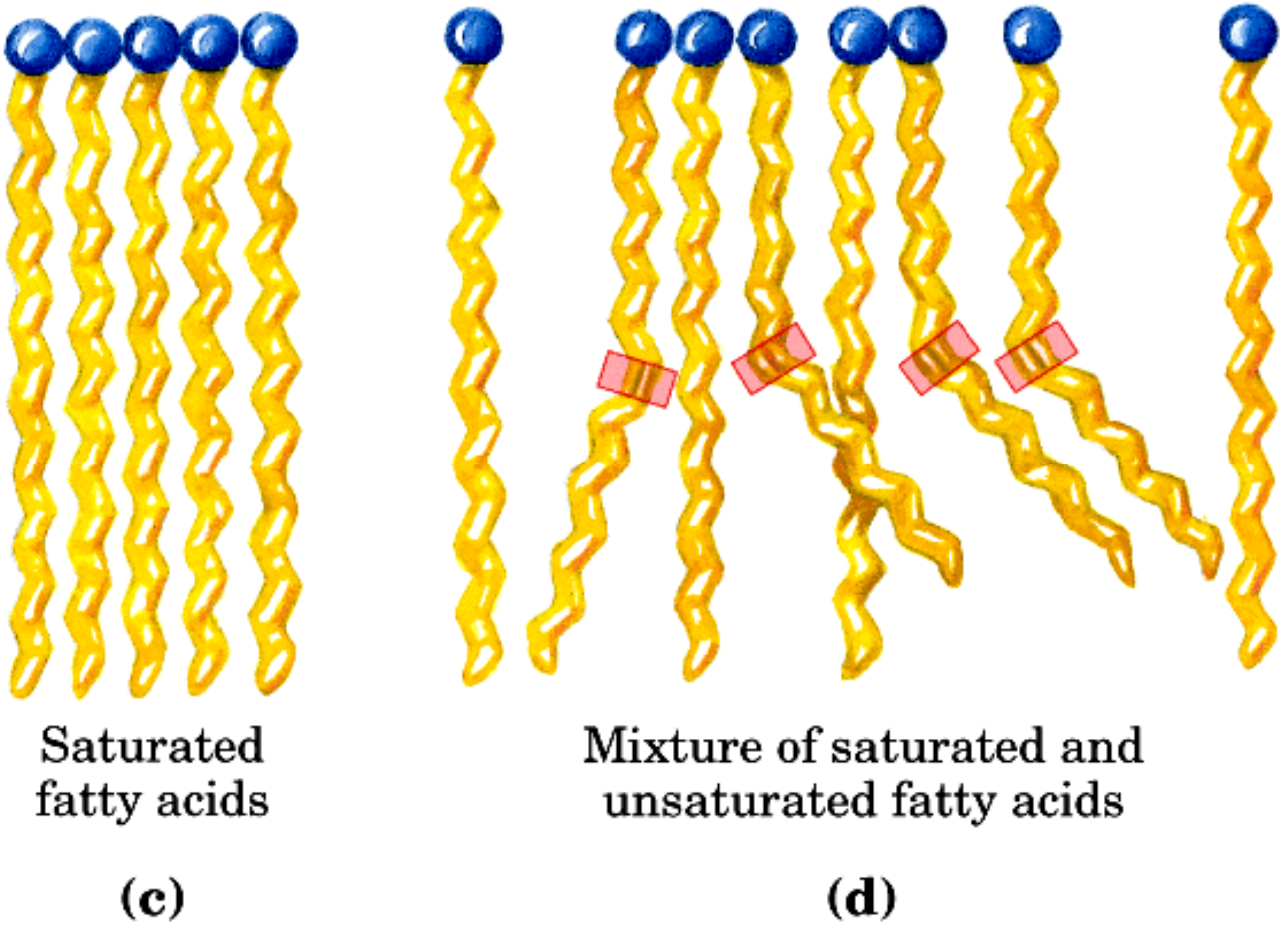


Figure : Effect of *cis* configuration on the packing chains of amino acids

Derived lipids-FAs

- **Chemical Properties- reactions of FAs**
  - **Rexns due to the carboxylic acid include:**

1. Salt formation – produce soap
2. Ester formation – formations of fats and oils
3. Amide formation - in sphingolipids

Derived lipids-FAs

- **Rexns due to double bonds in the side chain:**

1. Addition reactions-
   - hydrogenation, halogenation…
2. Oxidation - Lipid peroxidation
3. Isomerization- conversion of
   - *cis to trans* .
   - non-conjugated to conjugated

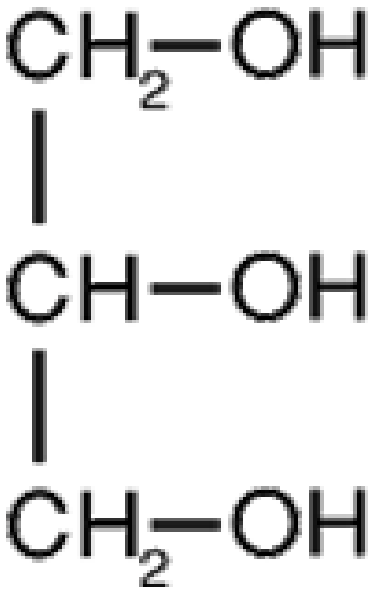
Derived lipids-Fatty alcohols

1-Glycerol:

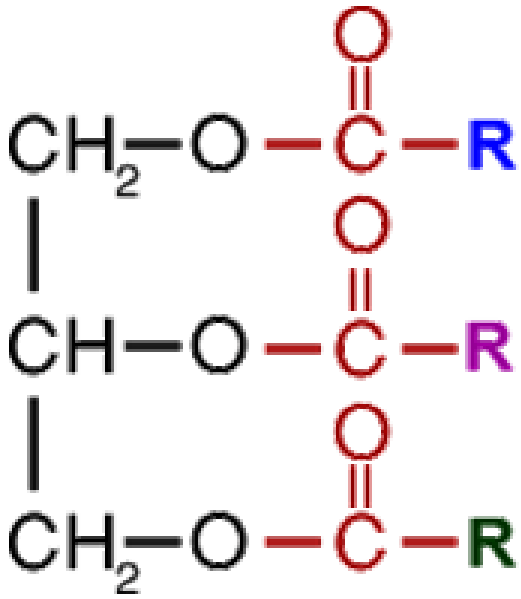
- It is a trihydric alcohol and has the popular name glycerin.
- It has the following properties:

1. Colorless viscous oily liquid with sweet taste.
2. On esterification with fatty acids it gives
   - Mono-, di- or triacyl-glycerol
3. It has a nutritive value by conversion into glucose
4. Enters in structure of phospholipids

Derived lipids-Fatty alcohols



glycerol

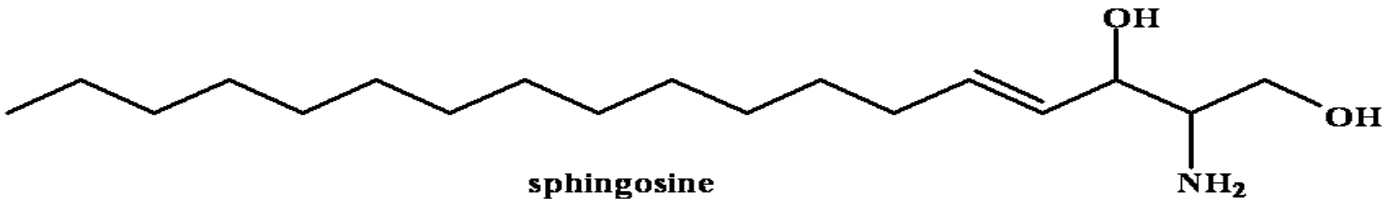


a triglyceride

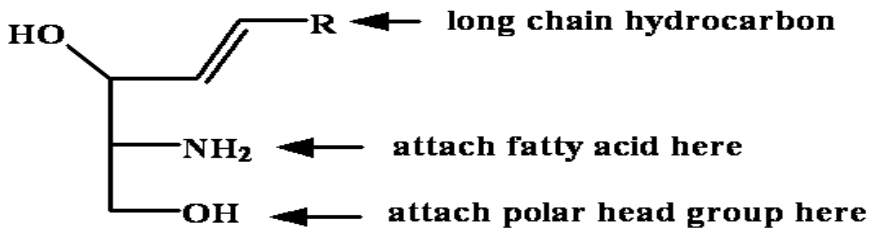
Derived lipids-Fatty alcohols

2-Sphingosine:

- It is the alcohol (monohydric) present in sphingolipids.
- It is synthesized in the body from serine and palmitic acid.
- Is a long-chain amino alcohol
- Is the alcohol part instead of glycerol



sphingosine



FATTY ACIDS AND HEALTH

- **Saturated**
  - Solids at room temperature
  - Found in meat and dairy products
  - **Are bad for health**
  - increase cholesterol levels - can lead to heart problems

FAs and Health cont.

- **Mono unsaturated**
  - contain just one C=C
  - thought to be neutral to our health
  - found in olive oil, groundnut oil, nuts, avocados

FAs and Health cont.

- **Poly unsaturated**
  - are considered to be '**good fats**'
  - contain more than one C=C bond
  - tend to be liquids at room temperature, eg olive oil.
  - include two important types
    - Omega 3 - fatty acids
    - Omega 6 - fatty acids

FAs and Health cont.

- **Omega 3 - fatty acids**
  - Lower the total amount of fat in the blood and can lower blood pressure and decrease the risk of cardiovascular disease
  - Example 1: EPA (Eicosapentaenoic acid) 20:5(n-3).
    - ✓ Omega-3,
    - ✓ all-cis –eicosa-5,8,11,14,17 pentaenoic acid

FAs and Health cont.

- Example 2: DHA (Docosahexaenoic acid) 22:6 (n-3).
  - ✓ omega-3,
  - ✓ all-cis -docosa-4,7,10,13,16,19-hexaenoic acid

- **Omega 6 - fatty acids**
  - Reduce the risk of cardiovascular disease but can contribute to allergies and inflammation

FAs and Health cont.

- **Trans fatty acids**
  - Have recently gained notoriety as being worse with respect to heart disease than even saturated fatty acids.
  - Are found in a variety of cookies, chips, and commercial baked goods.
  - Can also be produced when oil is used for frying foods.

FAs and Health cont.

- **Decomposition products of fatty acids**
  - Double bonds can also be oxidized and cleaved to aldehydes and carboxylic acids when they sit in air for too long.
  - This is what results in rancidity of oils.

2. SIMPLE LIPIDS

- Composed of fatty acids and alcohol components
- Include
  - ✓ Acylglycerols
  - ✓ Ether acylglycerols
  - ✓ Sterols and their esters and
  - ✓ Wax esters
- They are called neutral because they are uncharged due to absence of ionizable groups

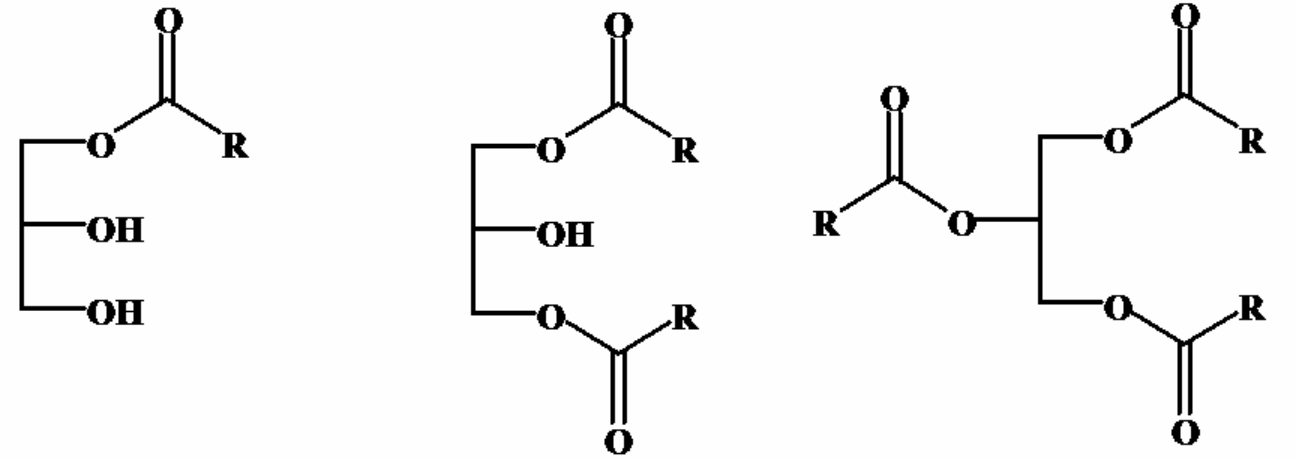
SIMPLE LIPIDS cont.

A. Acylglycerols

- Are the predominant constituent in oils and fats of commercial importance.
- Glycerol
  - ✓ can be esterified with one, two, or three fatty acids, and
  - ✓ the individual fatty acids can be located on different carbons of glycerol

SIMPLE LIPIDS cont.

- The terms:
  - monoacylglycerol, diacylglycerol, and triacylglycerol are preferred to the older names mono-, di-, and triglycerides.



SIMPLE LIPIDS cont.

- **Triglycerides (TGs)**
  - A large proportion of FAs in biological systems exist as TGs
    - This is the primary storage form of body fat.
    - TGs are the most common component of edible fats and oils

SIMPLE LIPIDS -TGs

- **Types of triglycerides**
- **Simple triglycerides:**
  - If the three fatty acids connected to glycerol are of the same type, e.g., tripalmitin.
- **Mixed triglycerides:**
  - If the three fatty acids connected to glycerol are of different types.
  - Natural fats are mixtures of mixed triglycerides with a small amount of simple triglycerides.

SIMPLE LIPIDS -TGs

- **Physical properties of fat and oils:**
- Freshly prepared or pure fats and oils are colorless, odorless and tasteless
  - Any color, odor or taste is due to association with other foreign substances (contaminants)
  - e.g., the yellow color of body fat or milk fat is due to carotene pigments (cow milk), in butter (bacteria give flavor, carotene gives color)

SIMPLE LIPIDS -TGs

- Fats have specific gravity less than 1 and, therefore, they float on water
- Fats are insoluble in water, but soluble in organic solvents
  - Since the carboxylates are esterified, and no longer can bear a negative charge, TGs are very nonpolar, and are therefore insoluble in water.

Example of Mixed Triglyceride

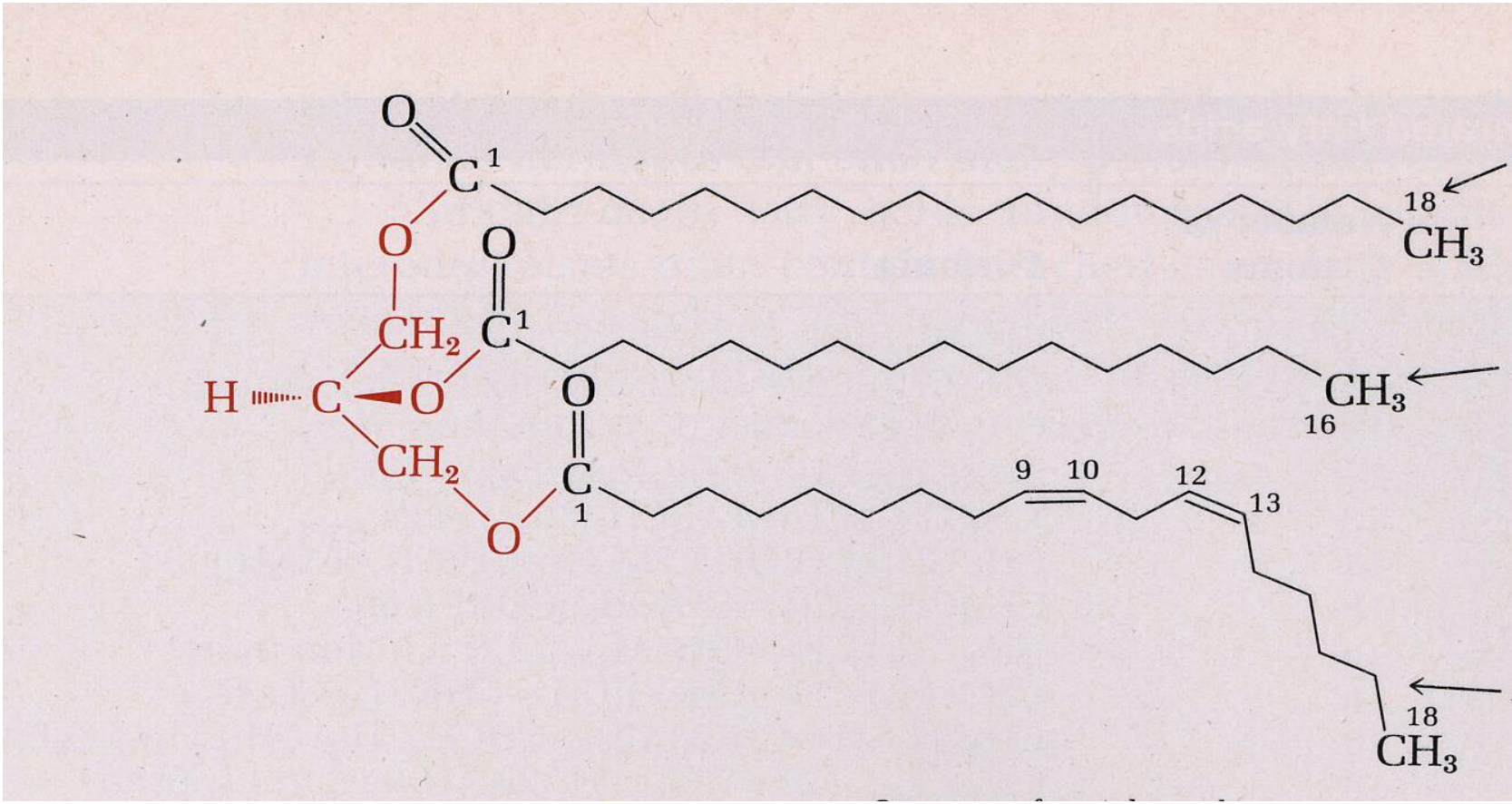
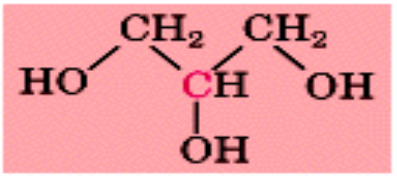
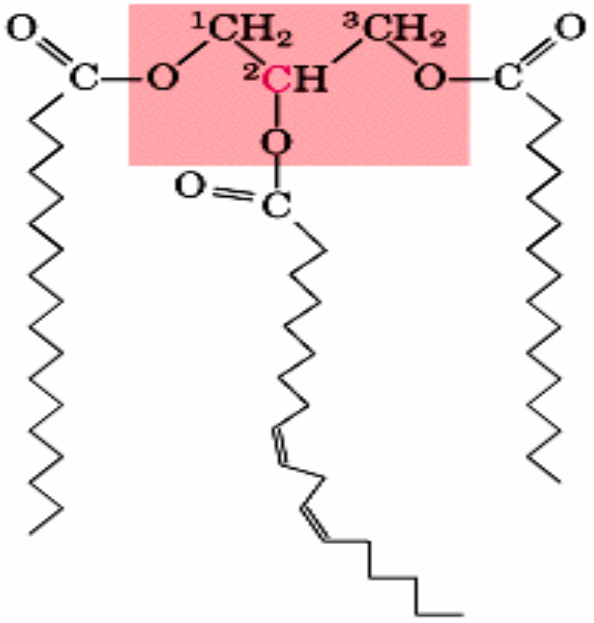


Figure : Glycerides



Glycerol



1-Stearoyl, 2-linoleoyl, 3-palmitoyl glycerol, a mixed triacylglycerol

SIMPLE LIPIDS -TGs

- Fats are solids or semi solids and oils are liquids
  - TGs rich in unsaturated FAs are generally liquid at room T° and are called **oils**
  - TGs rich in saturated FAs are generally semisolids or solids at room To and are called **fats**

SIMPLE LIPIDS -TGs

- Because of their high degree of order, saturated FAs pack together well and are held together by dispersion forces
  - as a result both saturated fatty acids and triglycerides derived from them are solids at room temperature

SIMPLE LIPIDS -TGs

- unsaturated FAs and the triglycerides derived from them do not pack as well in a crystal lattice as their saturated counterparts, and have weaker dispersion forces between their molecules
  - butter fat, for example, has a high content of saturated fatty acids and is a solid at room temperature
  - salad oils (from plant oils) have a high content of polyunsaturated fatty acids and are liquid at room temperature

SIMPLE LIPIDS -TGs

- Melting points of fats are usually low
- Melting points and boiling points are not usually sharp (most fats/oils are mixtures)
- When shaken with water, oils tend to emulsify

SIMPLE LIPIDS -TGs

- Chemical Properties of fats and oils

1. Hydrolysis
2. Saponification
3. Addition:
    - hydrogenation
    - iodination
4. Oxidation

A - Hydrolysis

➔Hydrolysis of TGs yields fatty acids

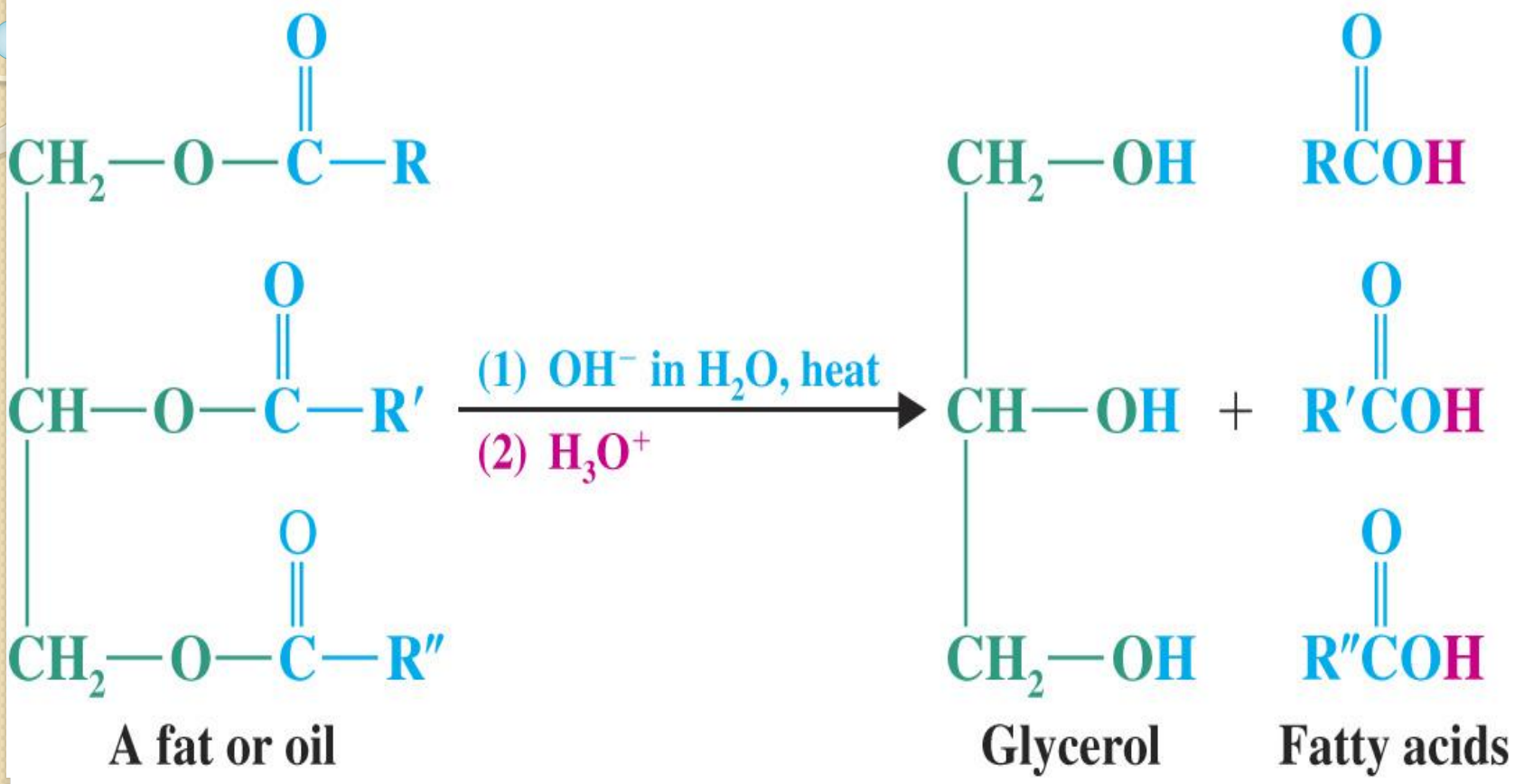


Figure (A): Hydrolysis

B - Saponification

➔Basic hydrolysis of TGs yields salts of carboxylic acids and glycerol

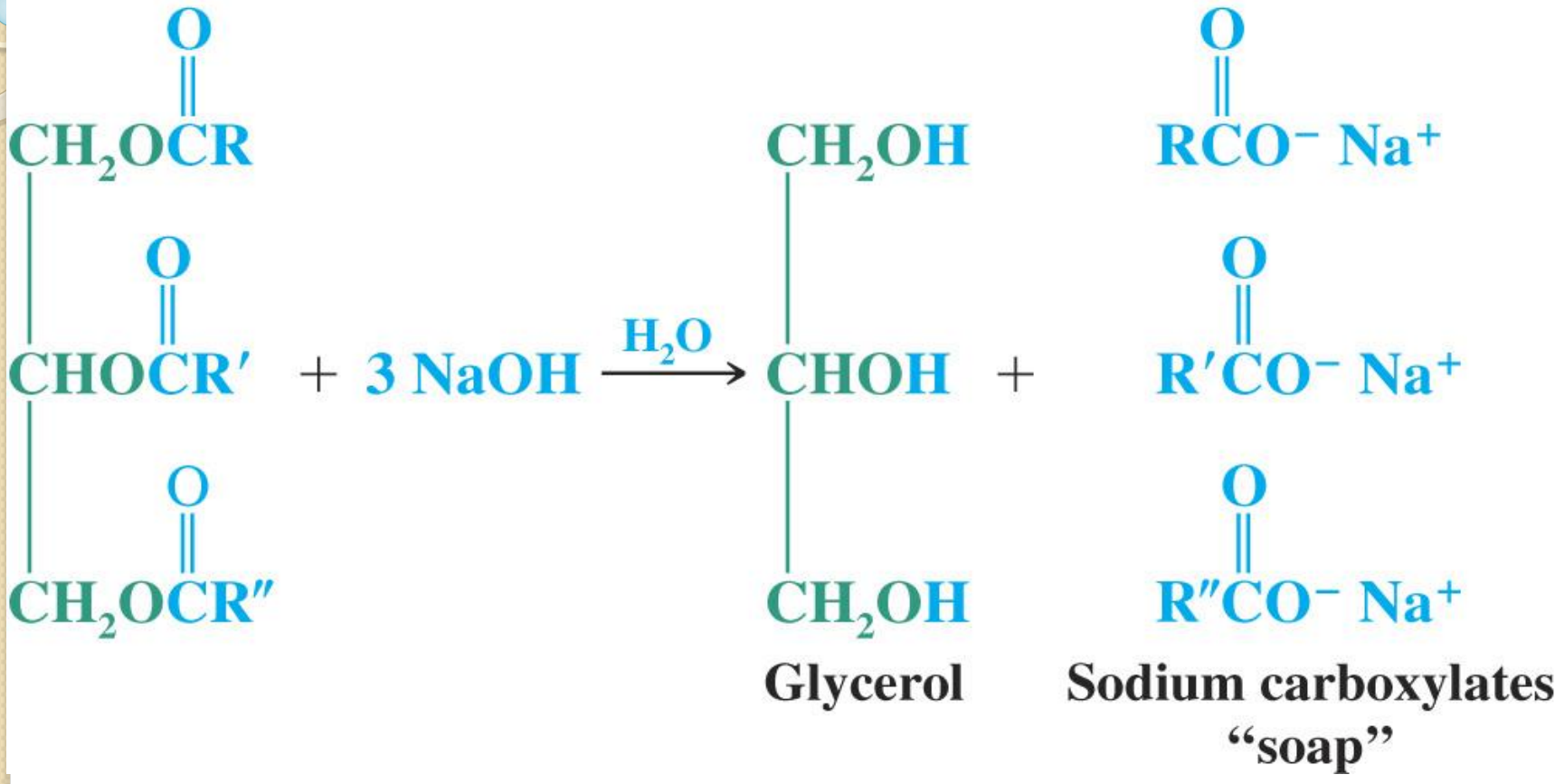


Figure (B): Saponification

C. Addition

Neutral fats containing unsaturated FAs have the ability of add hydrogen or halogens at the double bonds.

- e.g., hydrogen or **hydrogenation** and iodine or **iodination**

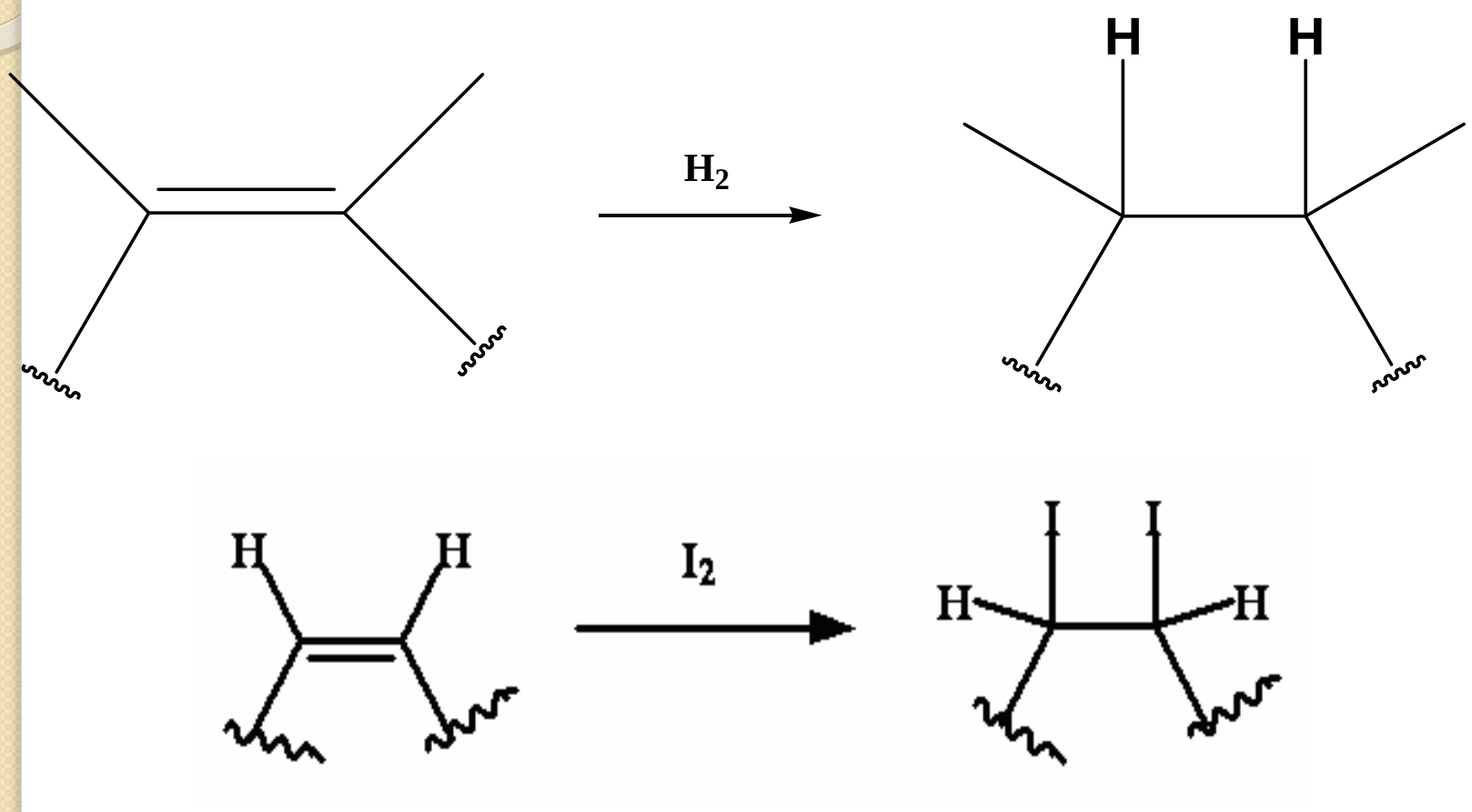


Figure (C): Addition

Hydrogenation

- **Hydrogenation**
  - It is a type of addition reactions accepting hydrogen at the double bonds of unsaturated fatty acids.
  - It can take place
- Artificially: food processing and
- Naturally: Rumen biohydrogenation (*via* microbial metabolism)

Hydrogenation

- **Artificial hydrogenation or hardening of oils**
  - Is done under high pressure of hydrogen and is catalyzed by finely divided nickel or copper and heat.
  - It is the base of hardening of oils (margarine manufacturing), e.g., change of oleic acid (liquid) into stearic acid (solid).

D. Oxidation

•This toxic reaction of TGs leads to unpleasant odour or taste of oils and fats developing after oxidation by oxygen of air, bacteria, or moisture.

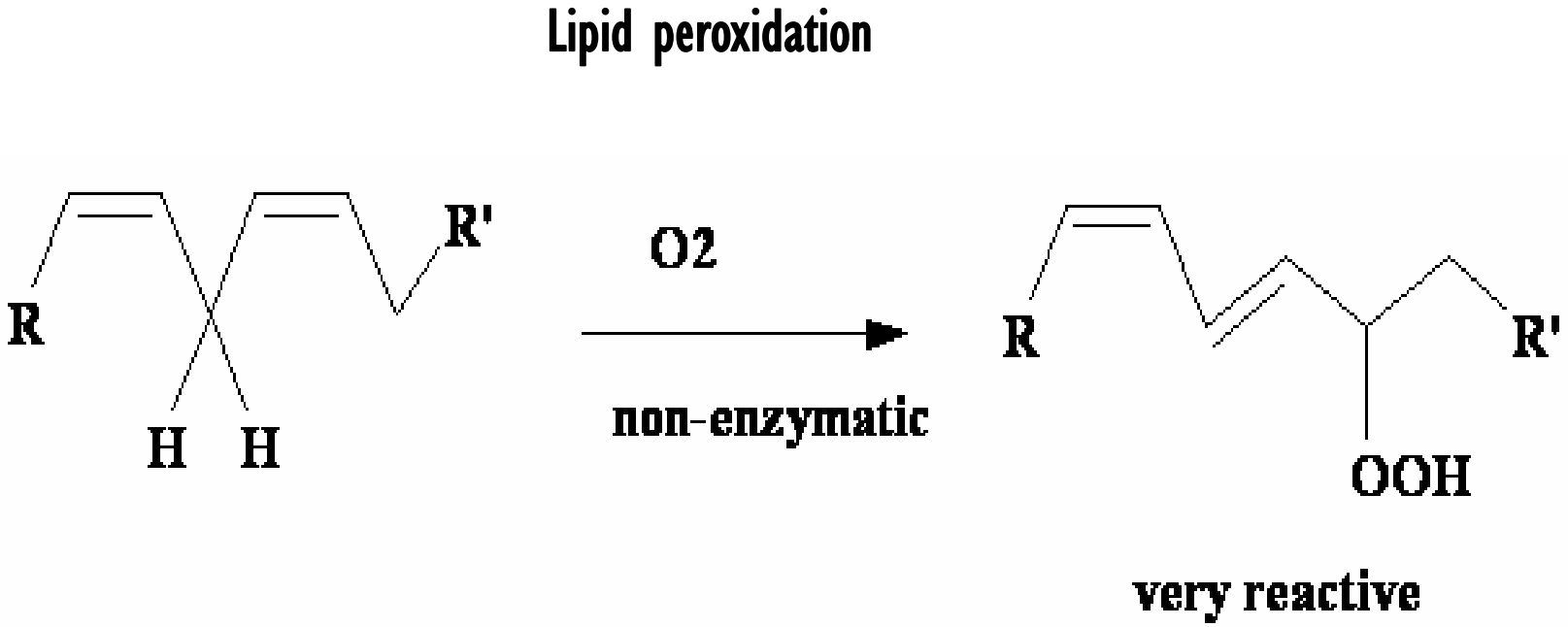


Figure (D): Oxidation

Lipid peroxidation

- a non-enzymatic reaction catalyzed by oxygen
- may occur in tissues or in foods (spoilage)
  - the hydroperoxide formed is very reactive and leads to the formation of free radicals which oxidize protein and/or DNA (causes aging and cancer)
- principle is also used in drying oils to form hard films

SIMPLE LIPIDS -TGs

- **Non-drying, semi-drying and drying oils**
  - based on the ease of autoxidation and polymerization of oils
    - important in paints and varnishes
  - the more unsaturation in the oil, the more likely the "drying" process

SIMPLE LIPIDS -TGs

- Non-drying oils:
  - Castor, olive, peanut, rapeseed oils
- Semi-drying oils
  - Corn, sesame, cottonseed oils
- Drying oils
  - Soybean, sunflower, hemp, linseed, tung, oiticica oils

SIMPLE LIPIDS-Waxes

B. Waxes

- Waxes (commonly called wax esters) are esters of fatty acids and long chain alcohols.
- **Simple waxes**
  - Are solids containing a monohydric alcohol (with a higher molecular weight than glycerol) esterified to long-chain FAs
  - Are usually esters of medium chain FAs (16:0, 18:0, 18:1ω9) and long chain aliphatic alcohols.

SIMPLE LIPIDS-Waxes

- Examples of these alcohols are palmitoyl alcohol, cholesterol, vitamin A or D.

- The alcohols range in size from C8 to C18.
- Are found on the surface of animals, plants, and insects and play a role in prevention of water loss.

SIMPLE LIPIDS-Waxes

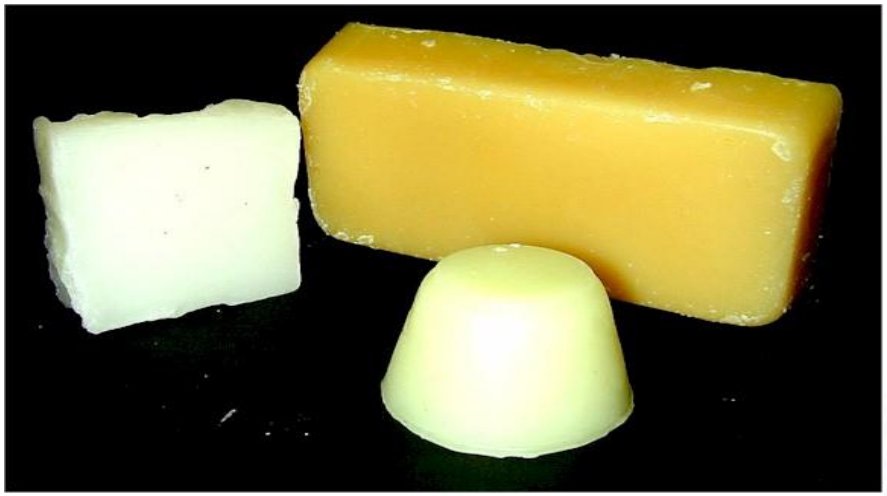
- **Complex waxes**
- Are formed from diols or from alcohol acids.
- Di- and triesters as well as acid and alcohol esters have been described.

SIMPLE LIPIDS-Waxes

- Simple waxes can be named by removing the -*ol* from the alcohol and replacing it with -*yl*, and replacing the -*ic* from the acid with -*oate*.
  - For example, the wax ester from hexadecanol and oleic acid would be named hexadecanyl oleate or hexadecanyl-*cis*-9-octadecenoate.

SIMPLE LIPIDS-Waxes

- Some of the long chain alcohols have common names derived from the fatty acid parent (e.g., stearyl alcohol).
- The C16 alcohol (1-hexadecanol) is commonly called cetyl alcohol. Thus, cetyl oleate is another acceptable name for this compound.
- Waxes of importance in foods as additives include beeswax, carnauba wax

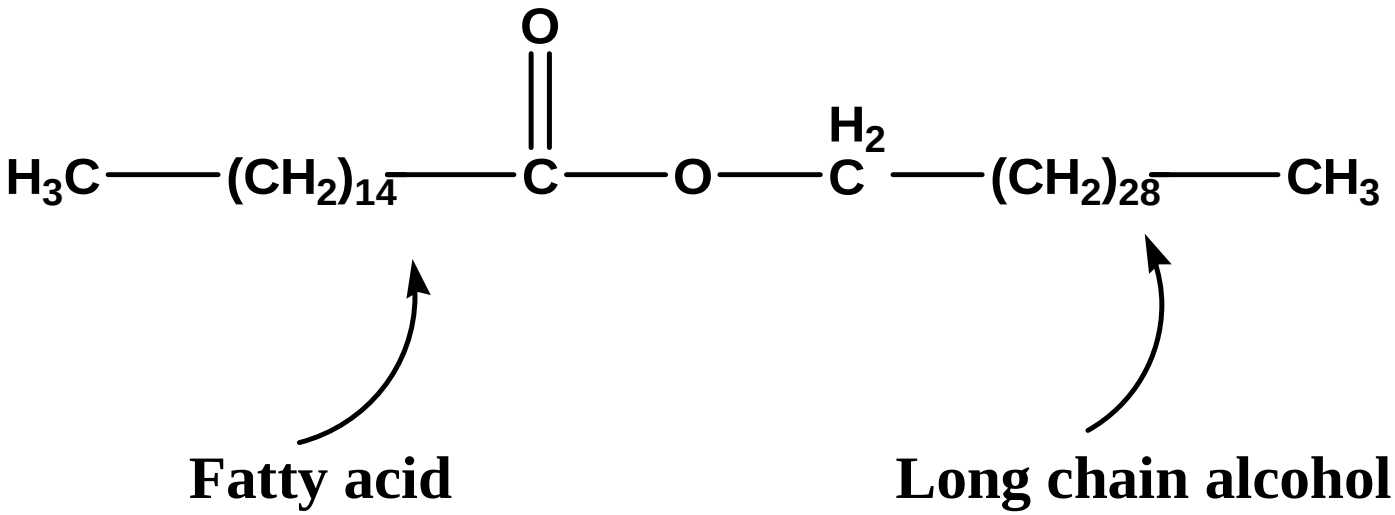


Bee's wax

Carnauba wax source

SIMPLE LIPIDS-Waxes

- Structure
  - Waxes are simple esters of fatty acids (usually saturated with long chain monohydroxy alcohols)



SIMPLE LIPIDS-Waxes

- Properties of waxes:
  - Waxes are
    - insoluble in water, but soluble in fat solvents
    - not easily hydrolyzed as the fats
    - indigestible by lipases
    - very resistant to rancidity
  - Thus they are of no nutritional value

SIMPLE LIPIDS-Waxes

- Waxes typically have fairly high melting points, espeically when compared to TGs
- Certain skin glands of vertebrates secrete waxes to protect hair and skin and keep it flexible, lubricated, and waterproof.

SIMPLE LIPIDS-Waxes

- Type of Waxes:
  - Waxes are classified into
    - true-waxes and
    - wax-like compounds

SIMPLE LIPIDS-Waxes

A-True waxes: include:

- **Bees-wax**
  - Is secreted by the honeybees that use it to form the combs.
  - It is a mixture of waxes with the chief constituent-mericyl palmitate
  - also includes some free alcohol and fatty acids

SIMPLE LIPIDS-Waxes

- **Spermaceti**
  - Contains cetyl palmitate (from whale oil)
  - useful for pharmaceuticals (creams/ointments; tableting and granulation)
- **Carnauba wax**
  - from a palm tree from Brazil – a hard wax used on cars and boats

3. COMPOUND LIPIDS

- Definition:
  - They are lipids that contain additional substances, e.g.,
    - ✓ sulfur,
    - ✓ phosphorus,
    - ✓ amino group,
    - ✓ carbohydrate, or
    - ✓ proteins beside FA and alcohol

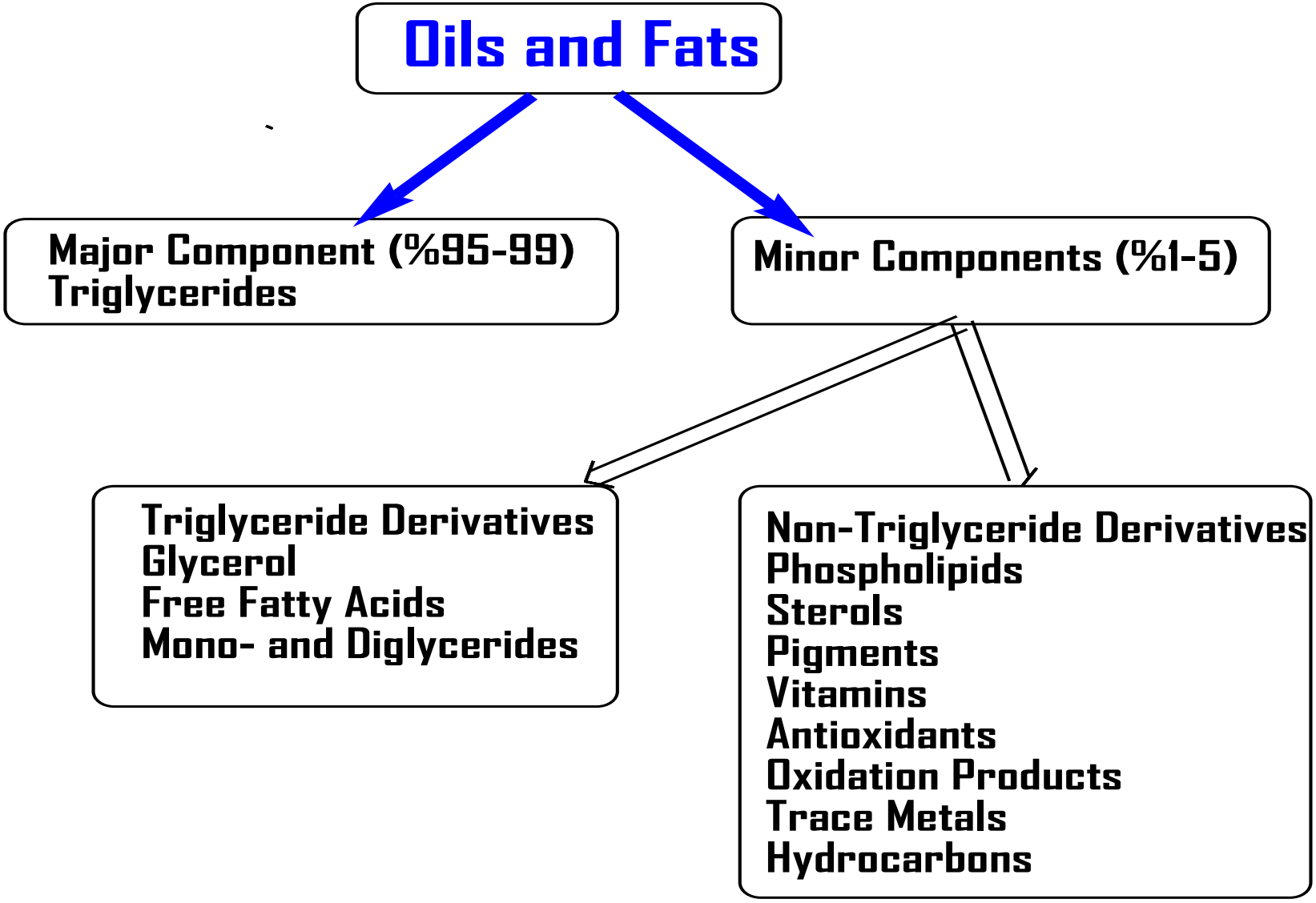
COMPOUND LIPIDS cont.

- Compound or conjugated lipids are classified into the following types according to the nature of the additional group:

1. Phospholipids
2. Glycolipids.
3. Lipoproteins
4. Sulfolipids and amino lipids.

Analysis and Identification of fats and oils (Fat Constants)

Composition of Fat and oils



Fat Constants cont.

- Fat constants or numbers are tests used for:

1. Checking the purity of fat for detection of adulteration.
2. To quantitatively estimate certain properties of fat.
3. To identify the biological value and natural characteristics of fat.
4. Detection of fat rancidity and presence of toxic hydroxy fatty acids.

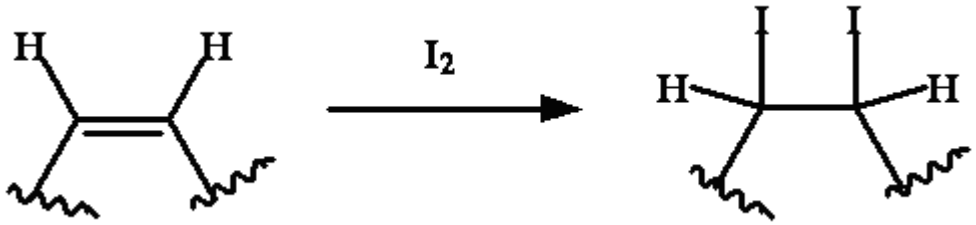
Fat Constants cont.

1. Iodine number (or value):

- Definition:
  - It is the number of grams of iodine absorbed by 100 grams of fat or oil.
- Uses:
  - It is a measure of the degree of unsaturation of the fat or oil, as a natural property.
  - frequently used to determine adulteration of commercial lots of oils

Fat Constants cont.

- Unsaturated FAs absorb iodine at their double bonds, therefore, as the degree of unsaturation increases iodine number and hence biological value of the fat increase.



Fat Constants cont.

- It is used for identification of the type of fat, detection of adulteration and determining the biological value of fat.
- Example of iodine number of some oils
  - Cottonseed oil: 103 –111
  - Olive oil: 79 – 88
  - Linseed oil: 175 –202

Fat Constants cont.

2. Saponification number (or value):

- Definition:
  - It is the number of milligrams of KOH required to completely saponify one gram of fat.
- Uses:
  - Since each carboxyl group of a FA reacts with one mole of KOH during saponification, the amount of alkali needed to saponify certain weight of fat depends upon the number of fatty acids present per weight.

Fat Constants cont.

- Thus, fats containing short-chain acids will have more carboxyl groups per gram than long chain fatty acids and consume more alkali, i.e., will have higher saponification number.
- Gives some clue as to the average size of fatty acids in a given sample of fat
  - Butter (large proportion of short chain FAs) sap. no. 220 – 230
  - Oleomargarine (long chain FAs) sap. No is 195 or less

Fat Constants cont.

3. Acids Number (or value):

- Definition:
  - It is the number of milligrams of KOH required to neutralize the free fatty acids present in one gram of fat.
- Uses:
  - It is used for detection of hydrolytic rancidity because it measures the amount of free fatty acids present.

Fat Constants cont.

4. Reichert- Meissl Number (or value):

- Definition:
  - It is the number of milliliters of 0.1 N KOH required to neutralize the water-soluble fatty acids distilled from 5 grams of fat.
  - Short-chain fatty acid (less than 10 carbons) is distillated by steam.

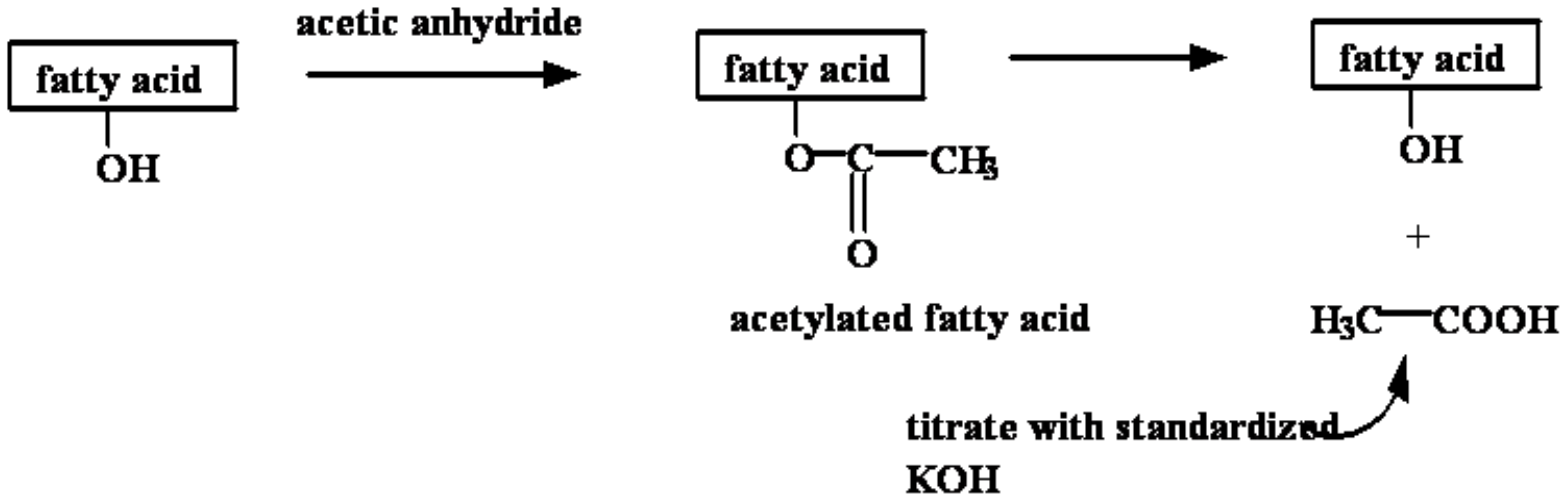
Fat Constants cont.

- Uses:
  - Measures the amount of volatile fatty acids (low MW and water soluble Fas)
  - This studies the natural composition of the fat and is used for detection of fat adulteration.
  - Butter that has high percentage of short-chain fatty acids has highest R-M number compared to margarine.

Fat Constants cont.

5-Acetyl Number (or value):

- Definition:
  - It is number of milligrams of KOH needed to neutralize the acetic acid liberated from hydrolysis of 1 gram of acetylated fat (hydroxy fat reacted with acetic anhydride).



Fat Constants cont.

- Uses:
  - Some fatty acids have hydroxyl groups
  - Hydroxyl groups can also be formed from oxidative rancidity
  - The acetyl number gives the proportion of these hydroxyl-containing fatty acids in a given sample of fat or oil
  - The **natural** or **rancid fat** that contains fatty acids with free hydroxyl groups are converted into acetylated fat by reaction with acetic anhydride.

Fat Constants cont.

- Thus, acetyl number is a measure of number of hydroxyl groups present.
- It is used for studying the natural properties of the fat and to detect adulteration and rancidity.
  - examples:
    - castor oil – 146 –150
    - cod liver oil – 1.1
    - cottonseed oil – 21 – 25
    - olive oil – 10.5
    - peanut oil – 3.5